SPACE Area Courses (AA 2023-2024)

- **Introduction to General Relativity**
  Lecturer: Prof. Salvatore Capozziello
  Email: salvatore.capozziello@unina.it
  Period: November-December | Hours: 24
  Teaching mode: in presence
  The course intends to provide an introduction to General Relativity for which knowledge of the basic principles of Special Relativity, Electromagnetism, and Classical Mechanics is required. It is aimed at graduates in engineering, physics and mathematics.

- **Introduction to Cosmology**
  Lecturer: Dr. Micol Benetti and Dr. Rocco D'Agostino
  Email: micol.benetti@unina.it, rocco.dagostino@unina.it
  Period: November-December | Hours: 24
  Teaching mode: in presence
  The course addresses the theoretical foundations of modern cosmology and the observational basis of the standard cosmological model. The main physical concepts and fundamental events in cosmic history are introduced, including the theory of inflation, the generation of cosmic microwave background anisotropies from primordial inhomogeneities, and the structure formation process.

- **Introduction to Astroparticle Physics**
  Lecturer: Dr. Ninetta Saviano
  Email: nsaviano@na.infn.it
  Period: January- February | Hours: 24
  Teaching mode: in presence
  The course aims to provide a broad overview of the impact of standard and beyond-standard particle physics in astrophysical and cosmological environments. In particular, we will consider the role of neutrinos, and gamma rays in connection with dark matter search, primordial black holes.

- **Introduction to Quantum Mechanics**
  Lecturer: Dr. Marco Chianese
  Email: marco.chianese@unina.it
  Period: March - April | Hours: 24
  Teaching mode: in presence
  The course aims to provide the main concepts of this very counterintuitive theory as well as the mathematical tools necessary to tackle quantitatively the subject. The Schrödinger equation will be introduced and studied for some quantum systems. Moreover, the path integral formalism will be described and used in the perturbation theory with the representation of Feynman diagrams.

- **Introduction to Aerospace**
  Lecturer: Prof. Riccardo Bevilacqua
  Email: bevilr@ufl.edu
  Period: March | Hours: 24
  Teaching mode: in presence
  This course will introduce the dynamics and control of space vehicles. The students will apply the theory implementing Matlab and Simulink functions whose goal is to simulate orbital flight. At the end of the course the students will be able to understand the space environment and how aerospace engineers navigate it and make choices on subsystems when designing their missions.

- **Introduction to Astrophysics**
  Lecturer: Prof. Guido Risaliti
  Email: guido.risaliti@unifi.it
  Period: May-June | Hours: 24
  Teaching mode: in presence
  The curse describes the physical processes determining the inner structure of stars, including hydrostatic equilibrium, the equation of state of stellar matter, nuclear fusion, radiative and convective transport, and the main mechanisms of interaction between radiation and matter. We will then discuss the main aspects of stellar evolution with a final brief treatment of the main properties of white dwarfs and neutron stars. Also, we will describe the most common techniques for measuring cosmic distances.

- **Quantum Information, Complexity and Black Holes – part1**
  Lecturer: Prof. Alioscia Hamma
  Email: alioscia.hamma@unina.it
  Period: January | Hours: 6
  Teaching mode: in presence
  This course is aimed at providing advanced tools from Quantum Information theory for the description of complex quantum phenomena and information scrambling in local quantum systems, with an emphasis on black holes. We will give a mathematical description of the spreading of information and how causality emerges in local quantum systems. The interplay between entanglement, complexity and information paradox in black holes will be discussed together with a survey of open research problems.

- **Black Hole Physics – part1**
  Lecturer: Dr. Vittorio De Falco
  Email: vittorio.defalco-ssm@unina.it
  Period: February | Hours: 6
  Teaching mode: in presence
  In this course, we aim at analysing the geometric features and structures of four classical black hole solutions in General Relativity (Schwarzschild, Kerr, Reissner–Nordström, and Kerr–Newman). Besides focusing on the mathematical aspects, we provide also the physical meaning and their applications in the current high-energy astrophysical panorama.

- **Standard Model of Fundamental Interactions**
  Lecturer: Prof. Francesco Sannino
  Email: sannino@cp3.sdu.dk
  Period: April | Hours: 12
  Teaching mode: in presence
  The course introduces the student to the fascinating world of fundamental interactions. The students will learn how to fuse quantum field theory, group theory, and other deep mathematical tools to bridge the gap between theory and experiments in particle physics. We will arrive at the frontier of our understanding of the ultimate laws of nature

Neutrino Astronomy: a closer look at the journey of this messenger
Lecturer: Prof. Antonio Marinelli
Email: antonio.marinelli@unina.it
Period: April - May | Hours: 12
Teaching mode: in presence
Starting with the description of non-thermal emission from Galactic and Extragalactic potential neutrino emitters the course aims to address key questions that arise with the last decade of high-energy neutrino observations.

Cosmic Distances in Astrophysics
Lecturer: Dr. Giulia De Somma
Email: giu.desomma@gmail.com
Period: June | Hours: 6
Teaching mode: in presence
In this course, students will explore the role of distance indicators in astrophysics, focusing on standard candles like Classical Cepheid pulsating stars and Type Ia Supernovae.

Classical and Quantum Modifications to General Relativity
Lecturer: Dr. Francesco Bajardi
Email: f.bajardi@ssmeridionale.it
Period: May | Hours: 12
Teaching mode: in presence
The course introduces the basic foundations of General Relativity and the shortcomings exhibited by the latter on different energy scales. Then, different modified gravity models, aiming to address part of these issues, are presented. The end of the course is devoted to the study of the ADM formalism and the quantum cosmological framework applied to General Relativity modifications.

Quantum field in curved space
Lecturer: Prof. Massimo Taronna
Email: massimo.taronna@unina.it
Period: May | Hours: 12
Teaching mode: in presence
In this course we will introduce the basic tools to understand Quantum Fields on curved backgrounds, from canonical quantization and path integral to Black Holes and Inflation, arriving at the most modern developments which are centered around the “Holographic Principle”.

Quantum Black Holes - part 2
Lecturer: Prof. Alioscia Hamma
Email: alioscia.hamma@unina.it
Period: May - June | Hours: 6
Teaching mode: in presence
In this short course, we build up upon the tools and problems given in the course Quantum Information, Complexity, and Black Holes and discuss some problems that naturally lead to open questions and potential research topics.

Black hole physics – part 2
Lecturer: Dr. Vittorio De Falco
Email: vittorio.defalco-ssm@unina.it
Period: June | Hours: 6
Teaching mode: in presence
This course delves into extra effects linked to black holes: gravitational wave emission, compact binary system motion, and accretion structure formation. These mathematical models are set in modern astrophysics, emphasizing current challenges and open problems from both theoretical and observational perspectives.

Relativistic positioning system from first principles
Lecturer: Prof. Lorenzo Fatibene
Email: lorenzo.fatibene@unito.it
Period: June | Hours: 12
Teaching mode: in presence
We explore free fall dynamics of particles and light rays to investigate gravitational fields using Lagrangian mechanics. We'll simulate satellite positioning systems, extract relativistic observables, and minimize complex functions.